Pied Currawongs (*Strepera graculina*): their Diet and Role in Weed Dispersal in suburban Sydney, New South Wales

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In this dietary study of an abundant population of pied currawongs (*Strepera graculina*) 1009 regurgitated pellets, collected over 25 months, were analysed. The percentage of pellets containing plant parts, mostly seeds of fleshy fruit, was high throughout the year (79-98%). The fruit of introduced plants was present in 45-91% of pellets containing plant material. The seeds of 46 species, of which 36 were introduced, were identified in their pellets.

Fruits of the family Oleaceae, including the three introduced species, *Ligustrum sinense* (small-leaved privet), *Ligustrum lucidum* (large-leaved privet) and *Olea africana* (wild olive) were the most significant part of the currawong diet for three months of the year, when at least one of these species was present in 54-74% of the pellets analysed. Other major plant species in the diet included the introduced *Pyracantha angustifolia*, *Morus nigra*, *Ochna atropurpurea*, *Solanum pseudocapsicum*, and the native *Elaeocarpus reticulatus*.

The proportion of pellets containing animal parts decreased from a value of 50-75% in the warmer months to 11-12% in the coldest months of the year. Few vertebrate remains were found in the pellets; the major animal components identified were bull-ants (*Myrmecia* spp.), beetles, and other insects.

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INTRODUCTION

A varied diet, intelligence and bold behaviour have contributed to making the pied currawong (*Strepera graculina*) one of the most successful and abundant birds in suburban environments throughout eastern Australia (Readshaw, 1968; Wimbush, 1969; Blakers *et al.*, 1984). Within twenty years of European colonization, pied currawongs had exploited new habitats and foods provided by settlement (Currey, 1966); and by the 1920's they were listed as one of the main dispersal agents of *Opuntia* spp. (Anon, 1920; 1927). More recently it has become clear that they are also agents for the dispersal of two abundant privet species (*Ligustrum sinense*, *L. lucidum*) in suburban Sydney (Walsh, 1965; Vellenga, 1966; Rose, 1973; Clyne, 1980). Despite their large size (41-51cm), abundance and role in weed dispersal, the diet of pied currawongs has not been studied in detail.

Rose (1973) systematically sampled regurgitated pellets, but many other accounts are largely anecdotal. Reports of their animal prey occur in Lea and Grey (1936), Marshall (1935), Roberts (1942), Readshaw (1965), Recher (1976), and Cooper and Cooper (1981) and include many insect orders as well as worms, snails, crabs, birds, mammals and carrion. Items of fruit eaten are frequently listed in catalogues of regional birdlife (Table 1).

From October 1976 to October 1978 the pellets regurgitated by pied currawongs in a garden in suburban Sydney were collected and their contents analysed. Objectives of this survey were: to record details of the larger contents of pellets, relating them to seasonal abundance of dietary components; to discuss the dietary findings in relation to the role of pied currawongs in weed dispersal in the Sydney region.

TABLE 1

Fruits and seeds reported in previous studies and additional to those recorded from Thornleigh

Identification[x]	Author	Type of Record +
MONOCOTYLEDONES		
Poaceae		
*Maize	Edwards 1922	N
DICOTYLEDONES		
Anacardiaceae		
**Schinus molle*	Rose 1973	P
*Pepper Tree	Cheney 1915	O
*Pepper Tree	Bourke 1949	O
Aquifoliaceae		
*Holly Tree	Vallenga 1966	O
Cactaceae		
*Prickly Pear	Morse 1922	N
*Prickly Pear	Anon 1920	N
*Prickly Pear	Anon 1927	N
Loranthaceae		
Mistletoe	Cleland, Maiden, Ferguson & Musson 1918	S
Loranthus	Lea and Gray 1936	S
Mistletoe	Keast 1958	N
Mistletoe	Rose 1973	P
Malvaceae		
#*Lagunaria patersonia*	Smith, Larkins & Pegler 1984	N
Mimosaceae		
#*Paraserianthes lophantha*	Smith, Larkins & Pegler 1984	N
Moraceae		
Moreton Bay Fig	Agnew 1922	O
Ficus macrophylla	Robertson 1969	O
Myrtaceae		
#*Eucalyptus caesia*	Smith, Larkins & Pegler 1984	N
Philesiaceae	Rose 1973	P
Rosaceae		
*Loquat	Roberts 1942	N
*Wild Raspberry	Marshall 1935	O
*Rowan	Vallenga 1966	O
*English Laurel	Vallenga 1966	O
Rutaceae		
*Orange and Lemon	Roberts 1942	O
Santalaceae		
Exocarpus stricta	Lea & Gray 1936	S
Solanaceae		
*Chillies	Bravery 1970	O
Vitaceae		
Native Grape	Cleland, Maiden, Ferguson & Musson 1918	S

x = The common or scientific name is listed in the same form as that given in the relevant paper.
* = introduced to Australia.
# = indigenous to Australia but not to the Thornleigh area.
+ N = not stated.
O = observation while feeding.
P = pellet
S = stomach content.

SITE DESCRIPTION

The study was carried out at Thornleigh, 19km north-west of Sydney, New South Wales; area features are illustrated in Fig. 1. Thornleigh is situated on a ridge 1-3km wide with the steep-sided valleys of the Lane Cove River to the south-east and Berowra Creek to the north-west. Both valleys are forested and the land to the west of Berowra

Creek is rural. Most of the suburban development consists of detached dwellings in gardens well vegetated with native and introduced trees and shrubs. The percentage of suburban development within a one to three kilometre radius of the study site ranges from 50 to 67% respectively, with the remainder being natural vegetation.

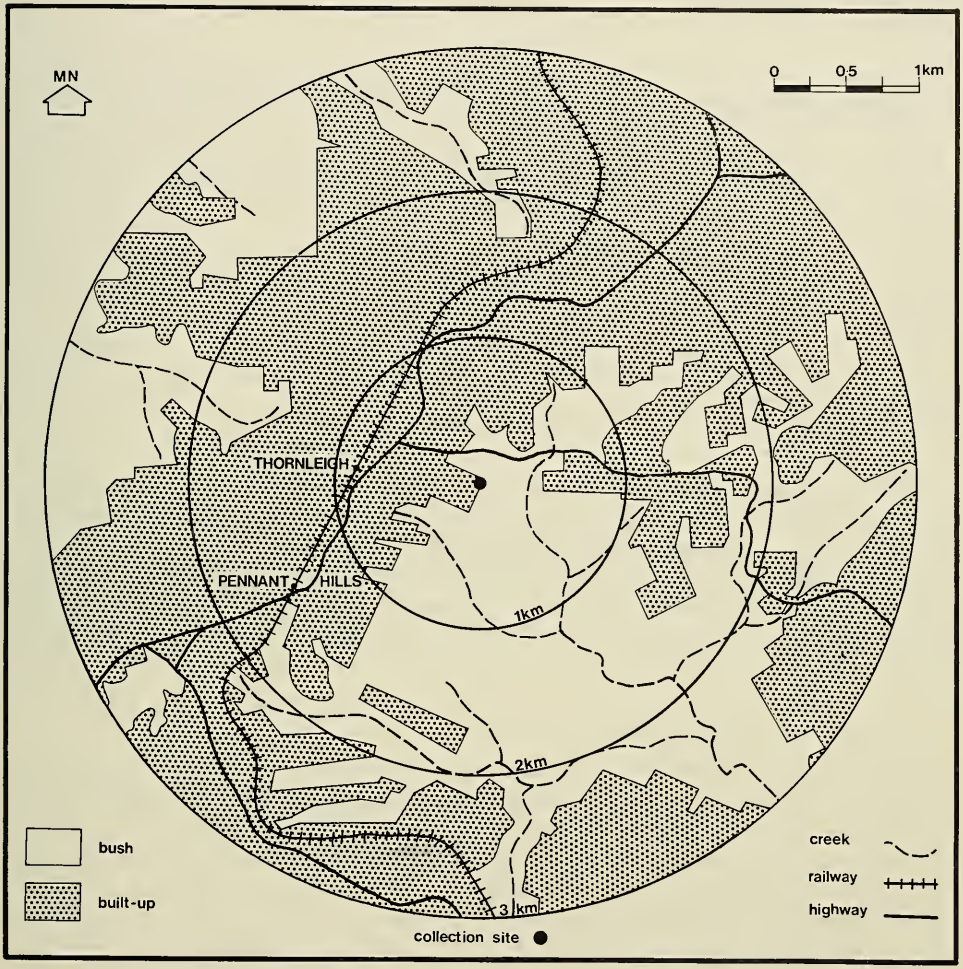

Fig. 1. Map of the environs of the collection site showing the distribution of the built-up areas and native vegetation.

The majority of the natural vegetation is woodland/open-forest (Specht, 1970) and is included in the Sandstone Complex, both wet and dry sclerophyll, of Specht *et al.*, (1974). Most of the slopes are free of weeds but *L. sinense* and other weeds are abundant along the creek and river banks.

Regurgitated pellets were collected at the junction of built-up and forested areas on the eastern side of Thornleigh. The collection site was a lawn surrounded by a dense growth of shrubs and trees; pied currawongs were attracted by bread, honey, seed, meat and water.

METHODS

Pellets

Pellets were collected twice a week over an area of approximately 150 m^2 from October 1976 to October 1978. In total 1 009 pellets were examined; the highest number sampled in any one month was 53 and the lowest 8 (Table 2). In October 1978 some 41 pellets were analysed.

TABLE 2

Number of pellets analysed in the 24 month period (October 1976–September 1978) and collected in the second year

Year	O	N	D	J	F	M	A	M	J	J	A	S
1 (Analysed)	51	41	39	51	43	22	39	49	43	53	49	40
2 (Analysed)	48	41	46	45	24	20	8	41	46	44	40	45
2 (Collected)	119	64	90	96	24	20	8	53	114	57	120	132

The sampled pellets were divided into three classes of coherence; coherent (collected intact or almost intact), partly coherent (collected in more than one piece), not coherent (collected completely fragmented). The lengths and widths of coherent pellets were measured and the contents of coherent and partly coherent pellets were then separated by stirring them in water and filtering. All pellets separated into individual fragments with this treatment. Only the larger fragments, identifiable at 40x magnification, were noted.

Component Identification

Most seeds were identified by comparison with seeds from known plants and by identification of young plants grown from seeds in the pellets. Some of the rarer seeds in the pellets were identified by the National Herbarium (Sydney). Scientific and vernacular names are listed in Table 3; botanical and common names follow the National Herbarium of New South Wales. Classification of invertebrates — based on Commonwealth Scientific and Industrial Research Organization, 1970 — was only attempted to class or order and rarely to genus. Many tiny invertebrate fragments remained unidentified. Some bone fragments were identified by the Australian Museum, Sydney. The number of different components, identified to class or genus for insects, and species for plants was tallied for each pellet.

The plant species most frequently present in pellets was assessed by counting the number of pellets in which a species was present in each month.

Bull-ants (*Myrmecia* species)

As the number of pellets containing bull-ants showed a strong seasonal pattern, an estimate of the activity of bull-ants was obtained by observing six nests for 5-10 minutes on one afternoon a week during the second year of the study. The largest number of ants present on the surface of the nest during this time was recorded. The average number of observed bull-ants was then calculated for each month.

TABLE 3

Species of fruit recorded in pellets

Classification (Common Name)	Highest frequency in any one month (%)				
	0-10	10-30	30-50	50-70	70-90
GYMNOSPERMAE					
Cupressaceae					
**Juniperus* sp. (Juniper)	X				
MONOCOTYLEDONES					
Arecaceae					
**Phoenix* sp. (Palm)		X			
Asparagaceae					
#0**Protasparagus aethiopicus* (Asparagus Fern)	X				
Asteliaceae					
+ *Cordyline rubra*	X				
Phormiaceae					
Dianella caerulea (Flax Lily)	X				
Smilacaceae					
Smilax glyciphylla (Thornless Smilax)	X				
Zingiberaceae					
#0**Hedychium gardnerianum* (Ginger Lily)	X				
DICOTYLEDONES					
Anacardiaceae					
#0**Toxicodendron succedaneum* (Rhus)		X			
Araliaceae					
0**Hedera helix* (Ivy)	X				
Polyscias sambucifolia		X			
Cornaceae					
**Dendrobenthamia capitata*	X				
Ebenaceae					
**Diospyros kaki* (Persimmon)			X		
Elaeocarpaceae					
Elaeocarpus reticulatus (Blueberry Ash)		X			
Euphorbiaceae					
Omalanthus populifolius (Poplar-leaved Omalanthus)	X				
Lauraceae					
#0**Cinnamomum camphora* (Camphor Laurel)					X
Magnoliaceae					
0**Magnolia grandiflora* (Evergreen Magnolia)	X				
Malvaceae					
+ *Lagunaria patersonia* (Norfolk Island Hibiscus)	X				
Meliaceae					
0 + *Melia azedarach* (White Cedar)				X	
Moraceae					
**Ficus carica* (Commercial Fig)			X		
Ficus rubiginosa (Port Jackson Fig)		X			
0**Morus alba* (Mulberry)					X
Myrtaceae					
Eucalyptus resinifera (Red Mahogany)	X				
+ *Syzygium paniculatum* (Lilly Pilly)		X			
Ochnaceae					
#0**Ochna atropurpurea* (Ochna)		X			
Oleaceae					
#0**Ligustrum lucidum* (Large-leaved Privet)			X		
#0**Ligustrum sinense* (Small-leaved Privet)				X	
#0**Olea africana* (Wild Olive)		X			
Phytolaccaceae					
#0**Phytolacca octandra* (Ink Weed)	X				
Pittosporaceae					
Pittosporum undulatum (Pittosporum)		X			

TABLE 3 (Cont'd.)

Classification (Common Name)	Highest frequency in any one month (%)				
	0-10	10-30	30-50	50-70	70-90
Proteaceae					
Persoonia pinifolia (Pine-leaf Geebung)		X			
Rosaceae					
#0**Cotoneaster glaucophyllus* (Cotoneaster)	X				
#0**Duchesnea indica* (Wild Strawberry)	X				
**Fragaria ananassa* (Strawberry)		X			
**Malus* sp. (Apple)		X			
**Prunus* sp. (Plum and Cherry)		X			
#0**Pyracantha angustifolia* (Orange Firethorn)			X		
**Pyrus* sp. (Pear)	X				
#0**Rhaphiolepis indica* (Indian Hawthorn)	X				
**Rubus x loganobaccus* (Loganberry)	X				
Rubiaceae					
Morinda jasminoides	X				
Rutaceae					
**Citrus sinensis* (Orange)	X				
Solanaceae					
#0**Solanum pseudocapsicum* (Madeira Winter Cherry)		X			
Sterculiaceae					
0+*Brachychiton acerifolius* (Illawarra Flame Tree)	X				
Verbenaceae					
#0**Lantana camara* (Lantana)		X			
Vitaceae					
0**Parthenocissus* sp. (Virginia Creeper)	X				
**Vitis labrusca* (Grape)		X			

* = introduced to Australia
+ = indigenous to Australia but not to the Thornleigh area
0 = present in the forest
# = reproductive in the bushland
No notation = native to the area

RESULTS

Pellets

Occurrence

The smallest number of pellets collected occurred in the autumn months (Table 2), a period which coincided with a seasonal decrease in the number of birds visiting the site (Buchanan 1983). Only eight pellets were collected in April, a deposition rate of 0.05 per square metre per month. The highest number occurred in September when 132 were collected, a deposition rate of 0.9 per square metre per month. The decrease in the number of pellets collected in July cannot be explained.

The average width of coherent pellets was 15mm with a standard deviation of 0.32. The average length of coherent pellets was 27mm with a standard deviation of 0.64. The maximum number of non-coherent pellets (Fig. 3) was recovered over the late autumn and winter months of April, May, June, July and August, when the pellets lacked animal remains to bind the seeds together (Fig. 4). The maximum number of coherent pellets was recorded in October (58%) and November (71%) when pellets contained large amounts of mulberry (*Morus alba*). The majority of these multiple fruits were relatively intact.

The data collected over 25 months showed that feeding is concentrated on one or a few items during the time needed to produce a pellet (Fig. 2). Almost 40% of pellets contained one component and more than 70% contained one or two.

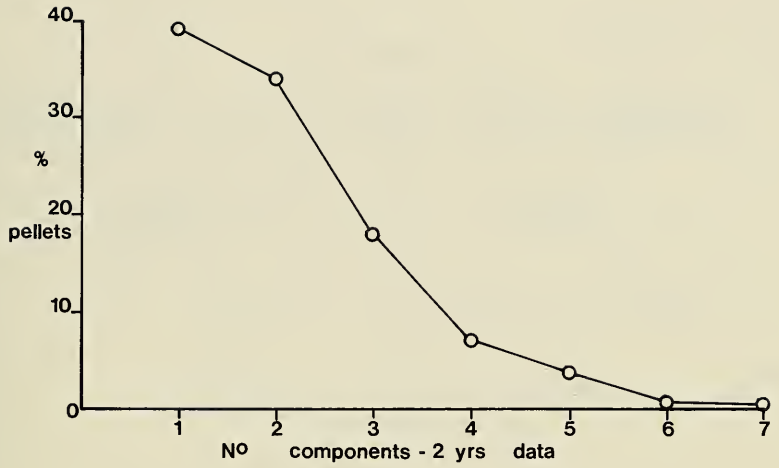

Fig. 2. Percentages of pellets containing different numbers of different components for the 25 month period.

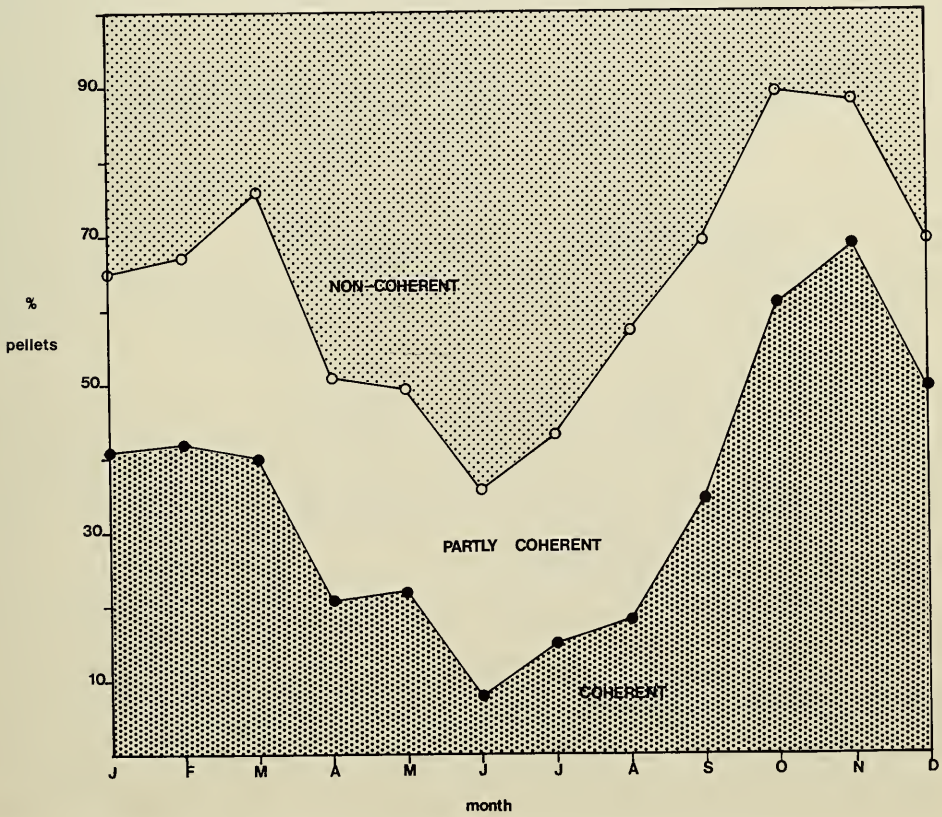

Fig. 3. Average monthly percentages of coherent, partly coherent and non-coherent pellets.

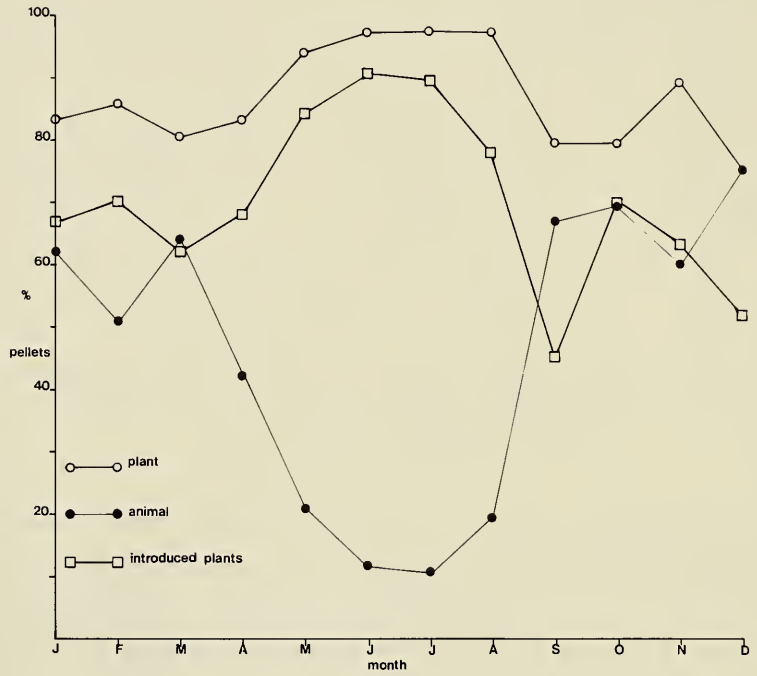

Fig. 4. Average monthly percentages of pellets containing plant parts, introduced plants and animal parts for the 25 month period.

Components and Seasons

Plant Content

The percentage of pellets containing plant parts remained high (79-98%) throughout the two years (Fig. 4). Fruit and seed was the major component (Table 3) but leaves and flowers were recorded in 3% and 0.6% of pellets examined. Almost half (22) of the 46 recorded fruits and seeds were present in less than 10% of the pellets in any one month (Table 3). Twenty-one species were abundantly represented, (Fig. 5).

Oleaceae, including *Ligustrum sinense*, *L. lucidum* and *Olea africana* were present in over 20% of pellets from May to September and peaked at 74% in July. *L. sinense* was the most abundant and was present in over 20% of pellets for three months of the year (Fig. 6). The consumption of *Olea africana* was highest in the early winter months but never peaked above 20% and *L. lucidum* was the most important in the later part of winter (26% in August).

Two other common weeds of urban native vegetation, *Ochna atropurpurea* and *Cinnamomum camphora*, were a prominent part of the diet in summer and autumn respectively. Insufficient sampling may have exaggerated the importance of *Cinnamomum*

camphora in April of the second year — only eight pellets were collected. *Morus alba* dominated the diet in October and November and *Pyracantha angustifolia* was consumed for several months of the year (Fig. 5).

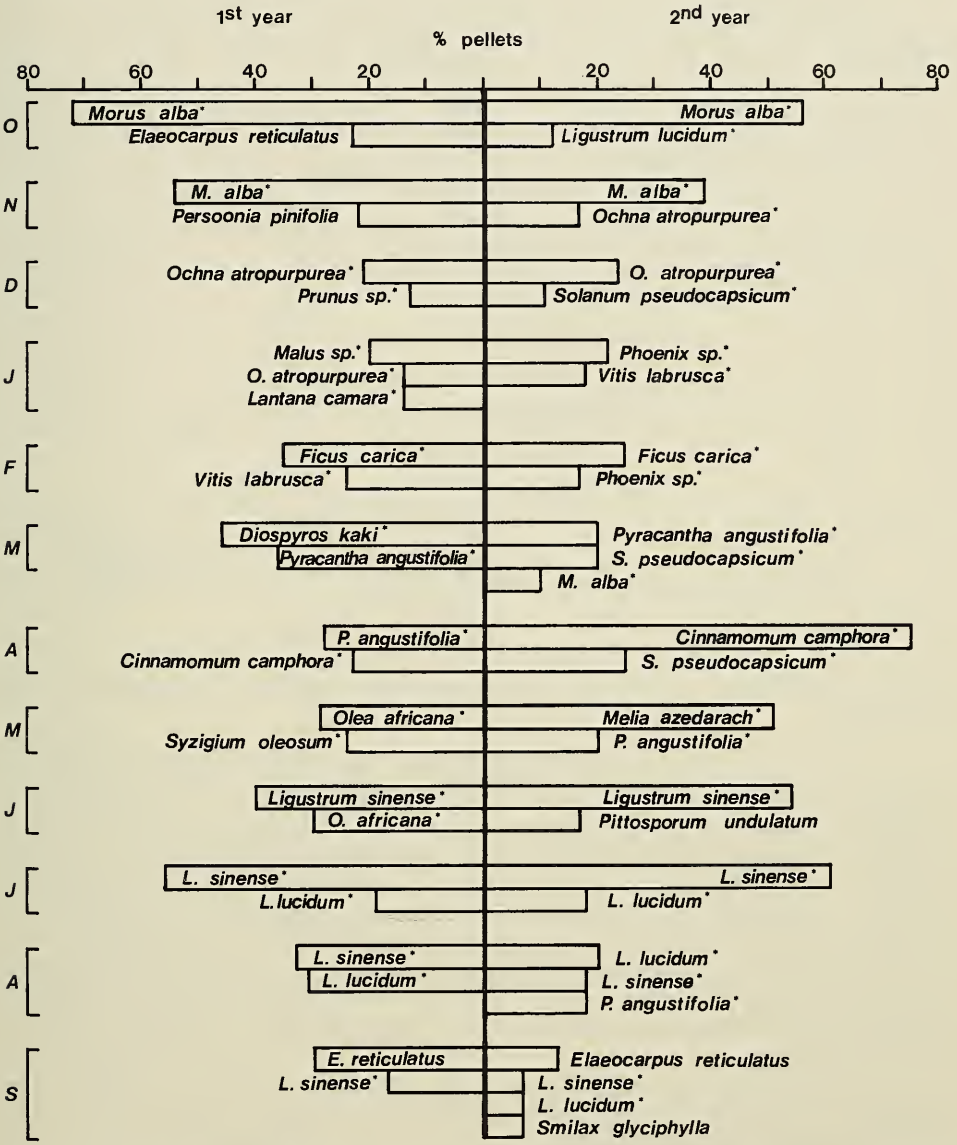

Fig. 5. The two plant species most frequently present in pellets for each month, showing changes between the first and second years of the 25 month period.

Introduced plants were present in 50-90% of pellets in all but one month (Fig. 4). Twenty-one of the 36 introduced plants recorded are present in the bushland and at least 15 of these produce seed in this situation. Only 10 of the 46 species were native to the Thornleigh area. The most important of these were *Elaeocarpus reticulatus*, *Persoonia pinifolia*, *Pittosporum undulatum* and *Smilax glyciphylla* (Fig. 5). Only *Elaeocarpus reticulatus* was

the dominant native species in any month (September). *Pittosporum undulatum*, which has a similar habit and similar habitat requirements to *Ligustrum sinense* and which is dispersed over the same months as the Oleaceae, was sparingly eaten.

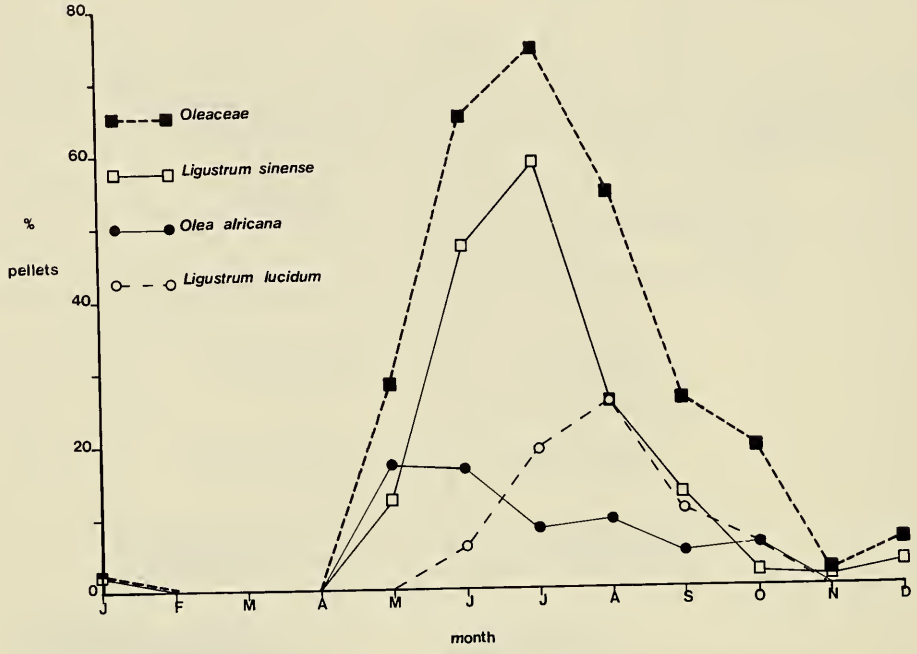

Fig. 6. Average monthly percentages of pellets containing Oleaceae, *Ligustrum sinense*, *Ligustrum lucidum* and *Olea africana*.

The data in Table 4 indicate that the fruit of the most favoured species have an average diameter greater than 5mm. Fruits of several species (*Morus alba*, *Ficus* sp., *Solanum pseudocapsicum* and *Pittosporum undulatum*) contained many seeds; but, the majority of fruit eaten contained only one or two seeds. For this latter group, the smaller the fruit is, the higher the number of seeds contained in a pellet. Fruits 5-6mm in diameter were represented by an average of 8-42 seeds per pellet while large fruit such as *Persoonia pinifolia* (14mm), *Syzygium paniculatum* (14mm) and *Melia azedarach* (13mm) were only represented by 2-5 seeds per pellet. Flesh and skin, but no seeds, of the very large fruited apple and persimmon were recorded in the pellets. The maximum number of seeds per pellet for *Ligustrum sinense* was 162, *Lantana camara* 131, *Ligustrum lucidum* 67, and *Ochna atropurpurea* 42.

The major fruits in the currawong diet ranged in colour from bright orange (*Diospyros kaki*, *Pyracantha angustifolia* and *Solanum pseudocapsicum*) to green (*Vitis labrusca* and *Persoonia pinifolia*) to black-blue for 7 of the 21 most frequent species.

Fruit Selection

Only ripe fruit was eaten or ingested by the pied currawongs. For green and pale-coloured fruit pied currawongs appeared to use means other than colour to determine ripeness. Just before *Melia azedarach* fruit first appeared in pellets, individual currawongs were observed to visit the tree; in each case the bird selected several fruits, held each one in the beak for a few seconds, and then dropped it. It is suggested that the birds were

assessing the yellowish coloured fruit for ripeness by testing the softness of the pericarp with their beaks or tasting the flavour of exuded juices.

TABLE 4

Fruit size and colour, number of seeds per fruit, average and maximum number of seeds in pellets

Species	Colour of fruit	Av. diam of fruit (mm)	No. seed per fruit	Av. No. seed per pellet	Max No. seed per pellet
Malus domestica	green or red	fruit very large — only skin and flesh ingested, no seed			
Diospyros kaki	orange	fruit very large — only skin and flesh ingested, no seed			
Morus sp.	dark red	may have many hundreds of seeds per pellet			
Phoenix sp.	red	26x15	1	3	10
Ficus sp.	brown	may have many hundreds of seeds per pellet			
Prunus nigra	dark red	approx 20	1	1	10
Pittosporum undulatum	orange	only consume seed	many	approx 50	approx 200
Vitis labrusca	green & purple	10-15	0-3	3	10
Persoonia pinifolia	green	14	1	2	9
Syzygium paniculatum	light purple	14	1	3	7
Melia azedarach	pale yellow	13	1	5	23
Solanum pseudocapsicum	orange	10	many	approx 60	approx 300
Cinnamomum camphora	black	10	1	4	23
Elaeocarpus reticulatus	blue	9	1	7	22
Pyracantha angustifolia	orange	8	5	approx 60	204
Olea africana	black	7	1	8	23
Ligustrum sinense	black	6	1	36	162
Ligustrum lucidum	black	6	1 or 2	18	67
Ochna atropurpurea	black	6	1	8	42
Lantana camara	black	5	1	42	131
Smilax glyciphylla	black	5	1 or 2	10	54

Animal Content

The percentage of pellets containing animal parts was highest (50-75%) in the warmer months but decreased to a low of 11-12% in the two coldest months of the year, June and July (Fig. 4). Remains of 7 major animal groups were recorded; these were Gastropoda, Arachnida, Diplopoda, Insecta, Amphibia, Aves and Mammalia.

Vertebrate remains were rare in the collected pellets and only 14 contained bone fragments (Table 5). The fragments in seven of the pellets were too small for identification, but of the remaining seven, two were from birds, two from frogs, two from house mice (*Mus musculus*) and one was a chicken bone.

The majority of the animals eaten were invertebrates — especially insects. Adult beetles, lepidopteran larvae and hymenopterans, — particularly bull-ants — were the most abundant remains (Table 5). The percentage of pellets containing bull-ants was high in the summer months, peaking at 47% in December, but fell to 0-4% during the winter months. This decrease was correlated with reduced bull-ant activity outside the nest (Fig. 7).

TABLE 5

Animal remains identified in pellets

Categories of Animal Remains	Month and Number of Pellets Containing Item											
	J	F	M	A	M	J	J	A	S	O*	N	D
Gastropoda (snails)							2		2			
Arachnida (spiders)										1		
Diplopoda (millipedes)					1							
Insecta												
Ephemeroptera (mayflies)										1		
Blattodea (cockroaches)					1							1
Mantodea (praying mantids)	1											
Dermaptera (earwigs)	3									1		
Orthoptera (grasshoppers & crickets)			1	1			1		1	2		1
Hemiptera (bugs)												2
Coleoptera (adult beetles)	30	16	9	8	10	3	4	7	40	61	28	38
Lepidoptera (moth & butterfly larvae)	5	2	1	1	1	2	3	3	12	19	9	10
other	1		2	1	1	1		1	1	2		
Hymenoptera (sawflies, wasps, bees & ants)												
Myrmecia sp. (bull-ant)	23	19	14	6	4	3		3	20	52	26	40
other	3	3	4	2	5		1	1	3	3	1	10
Unidentified	20	12	10	6	5		2	2	11	20	25	13
Bone	2	1	2	1		1	1	1	2	2		1
Egg shell							1	2	4			
Number of pellets examined	96	67	42	47	90	89	97	89	85	140	82	85

* = 3 months' data

DISCUSSION

Pellets and Diet

The examination of regurgitated pellets does not reflect the complete diet since only indigestible items are recorded (Dorst, 1971). The comparative volume of items in the pellets is also only a general guide to their importance in the bird's diet. For example, remains of lepidopteran larvae were usually only represented by the head capsule even though the larvae may have contributed a significant portion of the day's intake of food. On the other hand, favoured fruit items such as *Elaeocarpus reticulatus*, *Olea africana*, *Ligustrum sinense* and *L. lucidum* have thin fleshy layers around a hard endocarp and lost very little of their volume after digestion.

Despite the drawbacks outlined above the pellet studies reported here have augmented information on currawong diets in several ways. The importance of plant material in the omnivorous diet has been confirmed, but the wide diversity of fruits and seeds ingested — including many introduced species — has been documented in detail; the variety of animals eaten has also been demonstrated. Seasonal frequency in a number of animal and plant remains, and the small number of dietary components in individual pellets constitutes further evidence that currawongs are opportunistic feeders.

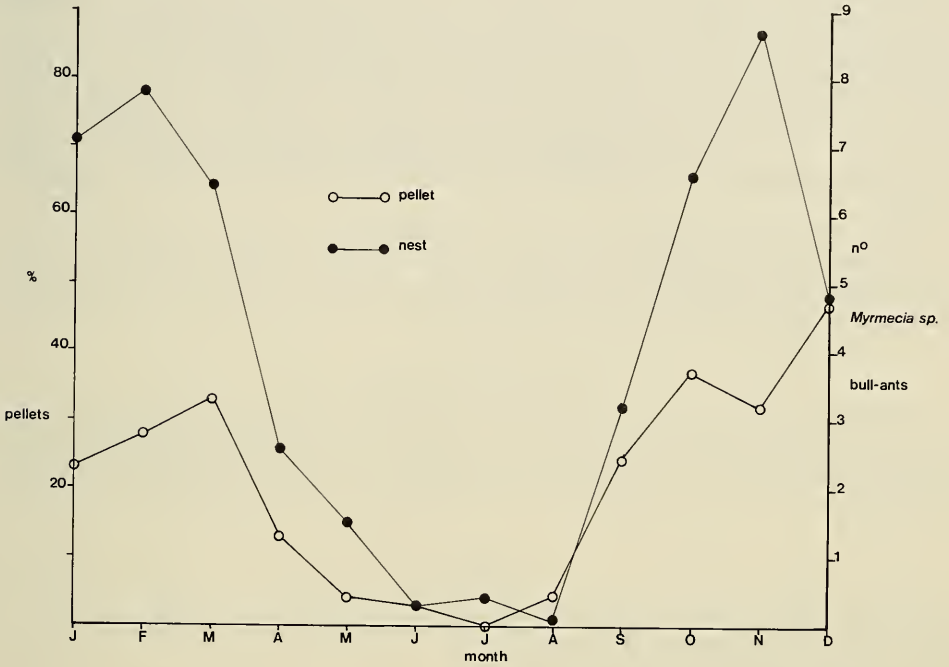

Fig. 7. Percentages of pellets containing bull-ants (*Myrmecia* spp.) in the 25 month period and the average number of bull-ants recorded at nest surfaces for one year.

Fruit Selection and Dispersal

The utilization of a large number of introduced plants as food resources by the currawong has wider implications, because of the potential for dispersal of weed species. Dispersal is only possible if the seed is undamaged by ingestion. Many seeds included in the pied currawong pellets were identified by germinating them and viability was high. *Ligustrum sinense* viability ranged from 83-91% (three samples of 50, 46 and 12 seeds), *Pittosporum undulatum* 100% (8 seeds) and *Toxicodendron succadaneum* 100% (6 seeds).

The Oleaceae (*Ligustrum sinense*, *L. lucidum* and *Olea africana*) seem to be ideally suited to dispersal by pied currawongs. The prolific crop is produced in winter at a time when pied currawongs form large feeding flocks in the warmer parts of their range, including Sydney (Buchanan, 1983). The black-blue colour of the fruit is one of the colours preferred by birds (Turcek, 1963). The size of the fruit is at the lower limit of the size taken by pied currawongs so that large numbers of fruit, and hence seeds are consumed. The ratio of fruit to animals eaten also increases in the winter months so that a higher proportion of fruit may be eaten than in summer. Deposition of at least some of the seed in suitable conditions for germination and establishment (i.e. along creeks and

rivers) is ensured by the fact that pied currawongs usually regurgitate pellets after drinking (Robertson, 1969; Clyne, 1980).

The average number of seeds deposited per square metre can be large; in June 1977 approximately 12 *Ligustrum sinense* seeds were dropped on every square metre of the collection site. The density of deposition away from the collection site would be much less, but the common occurrence of clustered *Ligustrum sinense*, *L. lucidum* and *Cinnamomum camphora* seedlings in natural vegetation confirms that seed dispersal by birds is important.

Some fruit appeared to be rejected by the birds. For example, *Cotoneaster glaucophyllus* is abundant in the study area and carried a prolific crop of fruit each autumn and winter, but was never present in more than 10% of pellets in any one month (Table 3). Rejection of *Cotoneaster glaucophyllus* cannot be explained. It was not on the basis of the thickness of the flesh (1.4mm) as this was greater than for *Elaeocarpus reticulatus* and the Oleaceae (0.8-1.2mm). Fruit size was within the range of the most frequently eaten species (Table 4) and by the colour it should have been selected (Turcek 1963).

As well as the dispersal of obviously palatable items, pied currawongs may also distribute the seed of woody fruit. The fruit of *Eucalyptus resinifera* was found in one pellet. Even if the inclusion of such fruit and viable seeds is a rare event, the possibility for dispersal of minor dietary items is important.

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